What is claimed is:

1. A device for separating a multi-constituent material into constituents, said device comprising:

a cylindrical wall having a first end, a second end and an inner radius, R_{wall}, said wall surrounding a chamber and defining a longitudinal axis;

means at said first end of said wall for converting the multi-constituent material into a multi-species plasma in said chamber within a radius, r_{source}, from said longitudinal axis to create cold ions of relatively low mass to charge ratio, M_1, and cold ions of relatively high mass to charge ratio, M_2;

a collector shaped as a hollow cylinder having outer radius R_{outer}, said collector centered on said longitudinal axis and positioned at said second end of said wall;

means for establishing crossed electric and magnetic fields (E x B) in said chamber to define a cutoff mass M_C, relative to a radial distance, a, from said axis, with $M_1 < M_2 \leq M_C$ and $a < R_{wall}$; and

means for controlling E x B to place said ions of relatively high mass to charge ratio, M_2, on trajectories having a radial apogee, r_{apogee}, into said collector with $r_{apogee} > R_{outer}$, and to place said ions of relatively low mass to charge ratio, M_1, on trajectories through said hollow collector.

2. A separator as recited in claim 1 wherein said controlling means is configured to place said ions of relatively high mass to charge ratio, M_2, on trajectories having a radial apogee, r_{apogee}, greater than the distance, a ($r_{apogee} >$ a).

3. A separator as recited in claim 1 wherein said electric field E is oriented radially with a positive potential (V_{ctr}) on said longitudinal axis and a substantially zero potential at said radial distance, a, from said longitudinal axis.

4. A separator as recited in claim 1 wherein said controlling means is configured to place said ions of relatively low mass to charge ratio, M_1, on helical trajectories of diameter $D_{low\ mass}$, and said collector has an inner radius R_{inner}, with $R_{inner} > D_{low\ mass} + r_{source}$.

5. A separator as recited in claim 1 wherein said establishing means comprises a plurality of ring shaped electrodes that are concentrically arranged about said axis and positioned at a said end of said wall to create said electric field (E) in said chamber.

6. A separator as recited in claim 1 wherein said establishing means comprises at least one coil mounted on said wall to create said magnetic field (B) in said chamber.

7. A device for separating a multi-constituent material into constituents, said device comprising:

a cylindrical wall having an inner radius, R_{wall}, said wall surrounding a chamber and defining a longitudinal axis;

means for converting the multi-constituent material into a multi-species plasma in said chamber within a radius, r_{source}, from said longitudinal axis to create ions of relatively low mass to charge ratio, M_1, and ions of relatively high mass to charge ratio, M_2;

a collector shaped as a hollow cylinder having outer radius R_{outer}, said collector centered on said longitudinal axis and positioned at said second end of said wall;

means for establishing a radial electric field (E_r) and an axially aligned magnetic field (B_z) in said chamber to create a plasma region of radius, a, from said axis, with $a < R_{wall}$; and

means for controlling said electric field (E_r) and said magnetic field (B_z) to place said ions of relatively high mass to charge ratio, M_2, on trajectories into said collector, and to place said ions of relatively low mass to charge ratio, M_1, on trajectories through said hollow collector.

8. A separator as recited in claim 7 wherein said controlling means establishes a cutoff mass, M_C, relative to a radial distance, a, from said axis in accordance with the equation:

$$M_C = zea^2(B_z)^2 / 8V_{ctr}$$

where "ze" is the ion charge.

9. A separator as recited in claim 8 wherein said controlling means establishes a cutoff mass, M_C, with $M_1 < M_2 \leq M_C$.

10. A separator as recited in claim 7 wherein said cylindrical wall has a first end and a second end, said converting means is positioned at said first end of said wall, and said collector is positioned at said second end of said wall.

11. A separator as recited in claim 7 wherein said radius, r_{source}, is sized to create a multi-species plasma having cold ions.

12. A separator as recited in claim 7 wherein said controlling means is configured to place said ions of relatively high mass to charge ratio, M_2, on trajectories having a radial apogee, r_{apogee}, with $r_{apogee} > R_{outer}$.

13. A separator as recited in claim 7 wherein said electric field, E_r, is established with a positive potential (V_{ctr}) on said longitudinal axis and a substantially zero potential at said distance, a, from said longitudinal axis.

14. A separator as recited in claim 7 wherein said converting means is configured to generate a plasma having a collisional density, n_c, in said plasma region.

15. A separator as recited in claim 7 wherein said converting means is configured to generate a plasma having a collision-less density in said plasma region.

16. A method for separating a multi-constituent material into constituents, said method comprising the steps of:

providing a cylindrical wall having inner radius, R_{wall}, said wall surrounding a chamber and defining a longitudinal axis;

converting the multi-constituent material into a multi-species plasma in said chamber within a radius, r_{source}, from said longitudinal axis to create cold ions of relatively low mass to charge ratio, M_1, and cold ions of relatively high mass to charge ratio, M_2;

centering a hollow cylinder having an outer radius, R_{outer}, on said longitudinal axis;

establishing crossed electric and magnetic fields (E x B) in said chamber to define a cutoff mass, M_C, relative to a radial distance, a, from said axis, with $M_1 < M_2 \leq M_C$ and $a < R_{wall}$; and

controlling E x B to place said ions of relatively high mass to charge ratio, M_2, on trajectories having a radial apogee, r_{apogee}, into said cylinder with $r_{apogee} > R_{outer}$, and to place said ions of relatively low mass to charge ratio, M_1, on trajectories through said hollow cylinder.

17. A method as recited in claim 16 wherein said controlling step places said ions of relatively high mass to charge ratio, M_2, on trajectories having a radial apogee, r_{apogee}, greater than the radial distance, a ($r_{apogee} > a$).

18. A method as recited in claim 16 wherein said electric field, E, is oriented radially with a positive potential (V_{ctr}) on said longitudinal axis and a substantially zero potential at said distance, a, from said longitudinal axis.

19. A method as recited in claim 16 wherein said controlling step places said ions of relatively low mass to charge ratio, M_1, on helical trajectories of diameter $D_{low\ mass}$, and said collector has an inner radius R_{inner}, with $R_{inner} > D_{low\ mass} + r_{source}$.

20. A method as recited in claim 16 wherein said establishing step is accomplished with a plurality of ring shaped electrodes that are concentrically arranged about said axis and positioned at a said end of said wall to create said electric field (E) in said chamber.